

PB86-116423

Proposed Goal of Applied
Aquatic Toxicology

(U.S.) Environmental Research Lab.-Duluth, MN

Oct 85



U.S. Department of Commerce
National Technical Information Service

NTIS

EPA/600/D-85/230
October 1985

A Proposed Goal of Applied Aquatic Toxicology

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TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO. EPA/600/D-85/230	2.	3. RECIPIENT'S ACCESSION NO. PB8 6 116423 /AS
4. TITLE AND SUBTITLE A Proposed Goal of Applied Aquatic Toxicology		5. REPORT DATE October 1985
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) C. E. Stephan		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency Environmental Research Laboratory-Duluth 6201 Congdon Boulevard Duluth, MN 55804		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Duluth, MN 55804		13. TYPE OF REPORT AND PERIOD COVERED
		14. SPONSORING AGENCY CODE EPA-600/03
15. SUPPLEMENTARY NOTES		
16. ABSTRACT It is proposed that "A major goal of applied aquatic toxicology is to be able to make a useful prediction concerning whether or not a specific addition of a toxic agent to a particular aquatic ecosystem will cause any unacceptable effect on that ecosystem." If this is a valid goal, it is important to the future of applied aquatic toxicology that biologists, ecologists, toxicologists and others concerned with environmental management reach some agreement concerning practical ways of distinguishing between acceptable and unacceptable effects on aquatic ecosystems.		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
18. DISTRIBUTION STATEMENT Release to public	19. SECURITY CLASS (This Report) unclassified	21. NO. OF PAGES 9
	20. SECURITY CLASS (This page) unclassified	22. PRICE

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The previous eight symposia on aquatic toxicology sponsored by the American Society for Testing and Materials have touched on nearly all aspects of aquatic toxicology. However, at these symposia no goals of aquatic toxicology have been defined so we can begin organizing and understanding this field by starting with first principles.

Constructing a logical framework for a field of science can be an interesting intellectual exercise, but, more importantly, it should aid in the development of the science. For example, the relevancy of research in aquatic toxicology should be judged on the basis of whether it will help meet a goal of aquatic toxicology, but such an evaluation is not possible without a clear statement of the goal(s). The purpose of this paper is to propose a statement of a major goal of applied aquatic toxicology and discuss some of its implications.

It might be argued that the only purpose of science is to generate data and derive relationships. This might be an acceptable objective of basic science. Applied science has the objective of using data and relationships in real-world situations. For applied aquatic toxicology I propose the following:

A major goal of applied aquatic toxicology is to be able to make a useful prediction concerning whether or not a specific addition of a toxic agent to a particular aquatic ecosystem will cause any unacceptable effect on that ecosystem.

This proposed goal is intended to cover such real-world applications as hazard assessment and derivation of water quality criteria.

Tools for Making Predictions

A variety of tools has been proposed for use in making predictions concerning effects of toxic agents on aquatic ecosystems. The relative usefulness (that is, field applicability) of predictions based on single species tests, microcosm tests, field-to-field extrapolations, and effects models has been discussed in several publications [1-3]. Although theoretical and philosophical discussions of the attributes of the various predictive tools might be interesting, the usefulness of the various tools should be experimentally determined by comparing how well they actually predict effects that occur in one or more specific situations.

Field studies to verify predictive effectiveness are usually costly; however they are necessary if questions concerning relative usefulness or field applicability are to be answered. In that the field measurements account for most of the cost of such projects, it would seem prudent to test several predictive tools simultaneously, rather than testing them in separate projects. Time and energy should be used to ensure that meaningful field tests are conducted, rather than being used to speculate about the results of such tests.

Some of the tools attempt to predict which biological variables, if any, will be affected and how much they will be affected. Other tools attempt to predict whether unacceptable effects will occur. How accurate a prediction must be to be useful will depend on the degree of environmental insult. Effects that are negligible and those that are catastrophic do not have to be predicted very accurately to allow decisions on acceptability. For example, if no biological variable will be affected by more than 0.1 % or if growth of a commercially and recreationally important species will be reduced by more than 90 %, it is not necessary to require that the

predictions be very accurate. If, however, the predicted amount of effect is near the limit of acceptability, the accuracy of the tool becomes very important.

Unacceptable Effects

Most tests of the usefulness of tools for predicting unacceptable effects will have limited value until practical ways of distinguishing between acceptable and unacceptable effects have been developed. Therefore, it is important to applied aquatic toxicology that some agreement be reached as to which effects are acceptable and which are not. Indeed, if the goal is to make useful predictions about unacceptable effects, one can readily conclude that an operational definition of unacceptable effects should be a major concern of aquatic toxicologists.

This does not imply, however, that aquatic toxicologists by themselves should attempt to define ways of distinguishing between acceptable and unacceptable effects on aquatic ecosystems. Nevertheless, aquatic toxicologists should take the lead in trying to ensure that the definitional need is quickly and adequately accomplished. They should begin working with other professions involved in environmental management to understand the complexities of the problem and to start examining various possible answers. Certainly, biologists, ecologists and toxicologists should be involved. In addition, many nonscientists in environmental management should also be involved.

Such an effort should not be constrained by existing laws and regulations. For example, unacceptable effects on aquatic ecosystems do not necessarily have to be defined in terms of either impaired uses or biological integrity as defined by current regulations. It should be expected that a

consensus might indicate ways in which existing laws and regulations can be improved. In addition, education of the public should be an integral component of the process, particularly to make the public aware that each possible answer has a "cost", whether it be the loss of some species in some situations, an increase in the price of a product, or an increase in costs for sewage treatment facilities. Because of the complexity of the problem, the answer(s) initially proposed should be reexamined carefully after use for a few years.

The emphasis on unacceptable effects has several implications. First, not all adverse effects should be considered unacceptable. For example, a small reduction in growth is adverse, but it might not be unacceptable. For each adverse effect it is necessary to determine what amount of that adverse effect is unacceptable. "Unacceptable" also more clearly implies a value judgment than does "adverse". People are the ones who make, use, and dispose of chemicals and products and they are the ones who should be involved in choosing among options concerning production, use and disposal. Choosing among options involves decisions concerning acceptability based on value judgments. Of course, a distinction between adverse effects and unacceptable effects will be unacceptable to those who feel that all changes from "normal" are unacceptable. On the other hand, for the protection of human health, the goal of assessment and management of risk to humans usually is to reduce risk to an acceptable level, rather than to entirely prevent adverse effects [4,5]. In many cases one of the most difficult decisions is the selection of the amount of effect that is unacceptable.

A second implication of the emphasis on unacceptable effects is that a new toxicity test should not be claimed to be better than an existing one just because it is more sensitive or because it detects previously unobserved

effects. The usefulness of a new single species or microcosm test should be judged on the basis of its ability to provide useful information about unacceptable effects. Novel tests and more sensitive tests might have great academic interest, but neither novelty nor sensitivity necessarily implies usefulness. An appropriate definition of unacceptable effects will undoubtedly have many other implications for procedures for conducting tests, calculating results, assessing hazard, and deriving water quality criteria.

A Suggested Beginning

Until a few years ago, aquatic toxicology was mostly a laboratory science concerned with generating data on the effects of toxic agents on various species. Recently, increased interest in the use of aquatic toxicological data to assess hazard and derive water quality criteria has resulted in concern about field applicability, that is, the usefulness of predictions concerning effects of pollution in the real world. This has resulted in some discussions and studies of field applicability.

Today, more discussions and studies are focusing on the usefulness of various tools for making predictions of adverse environmental effects. However, it is difficult to design, conduct, and interpret studies of the usefulness of procedures for assessing hazard or deriving water quality criteria if the distinctions between acceptable and unacceptable effects are not clear. Applied aquatic toxicologists should begin working with biologists, ecologists, and others concerned with environmental management to define operational differences between acceptable and unacceptable effects on aquatic ecosystems.

Acknowledgments

Steven F. Hedtke and John M. Neuhold provided useful discussion and comments during the development of this paper.

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